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(54) **POWER SUPPLY SYSTEM FOR ELECTRIC VEHICLE**

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B60L 11/00 (2006.01)
B60K 1/00 (2006.01)

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CPC . ***B60K 1/04*** (2013.01); ***B60L 11/00*** (2013.01); *B60K 2001/005* (2013.01); *B60K 2001/0438* (2013.01); *B60K 2001/0455* (2013.01); *B60Y 2306/01* (2013.01)

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USPC 307/9.1
See application file for complete search history.

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(57) **ABSTRACT**

A power supply system for an electric vehicle includes a battery, a power line, a connector, a separating operation device, a switch device, a switching operation member, and an interlock member. The switch device is configured to interrupt an electrical connection between the battery and the connector. The switching operation member is configured to be operated by an operator to open the switch device to interrupt the electrical connection. The interlock member is movable from a first position to a second position if the switching operation member has been operated by the operator to open the switch device to interrupt the electrical connection. The interlock member is configured to prohibit, at the first position, the operator from operating the separating operation device. The interlock member is configured to allow, at the second position, the operator to operate the separating operation device.

14 Claims, 6 Drawing Sheets

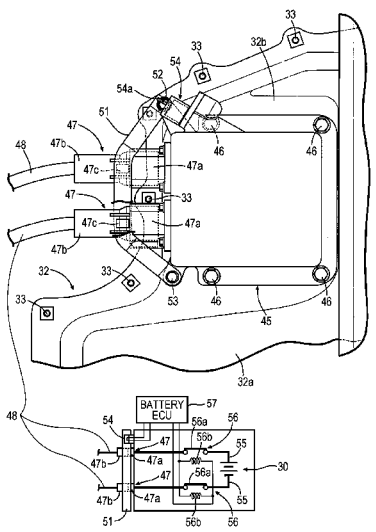

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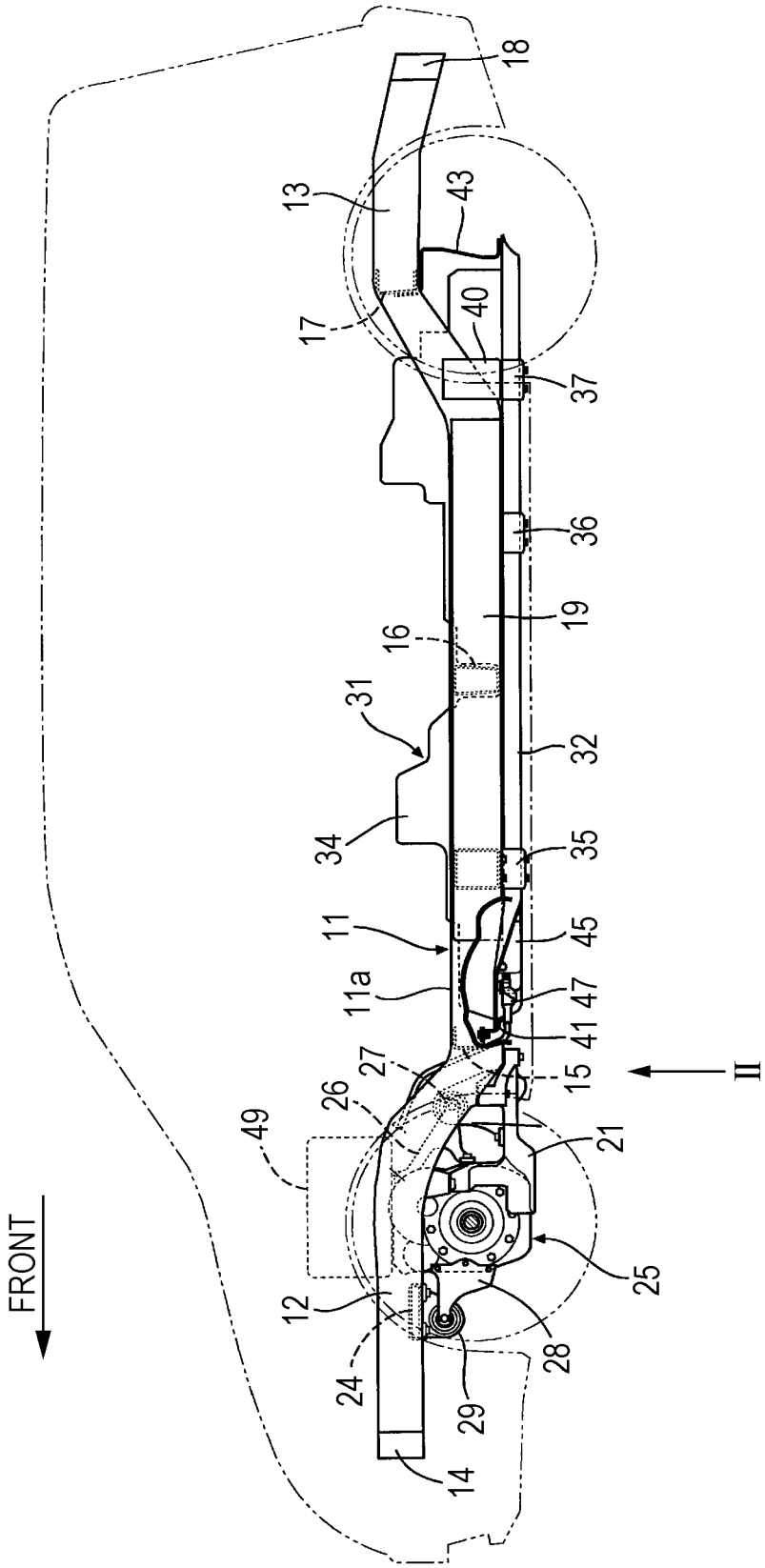
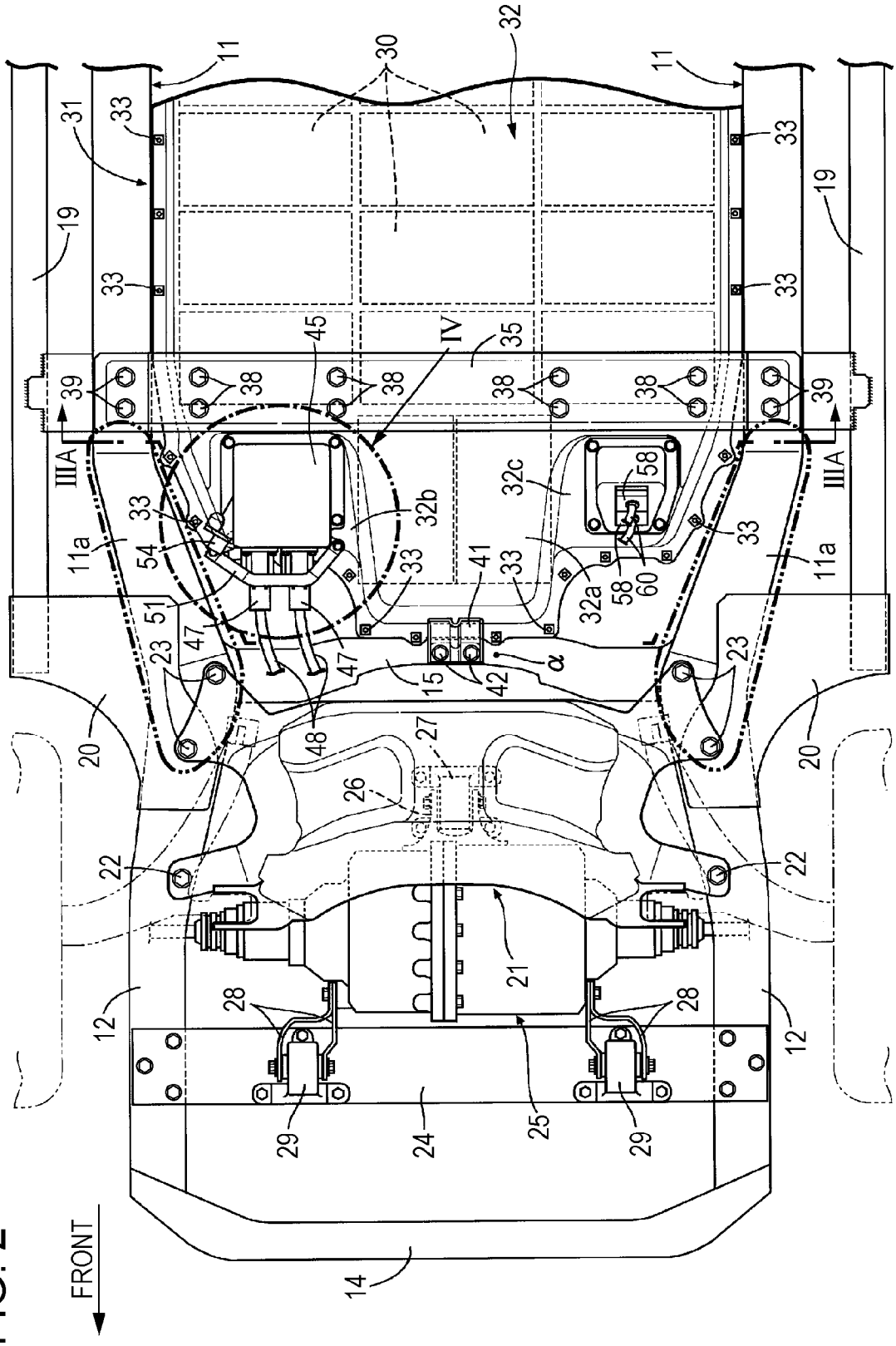
FIG. 1


18
13
43
17
40
37
36
19
16
31
32
34
35
11
45
11a
47
41
15
II
27
26
49
21
25
12
28
24
29
14
FRONT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30
32
11
31
33
19
33
19
33
33
45
IV
35
38
38
38
38
39
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IIIA
IIIA
32c
58
32b
33
33
11a
54
33
41
33
11a
32a
58
60
51
47
23
47
15
42
α
23
48
27
20
20
26
22
22
21
28
28
12
12
29
24
25
29
14
FRONT

FIG. 2

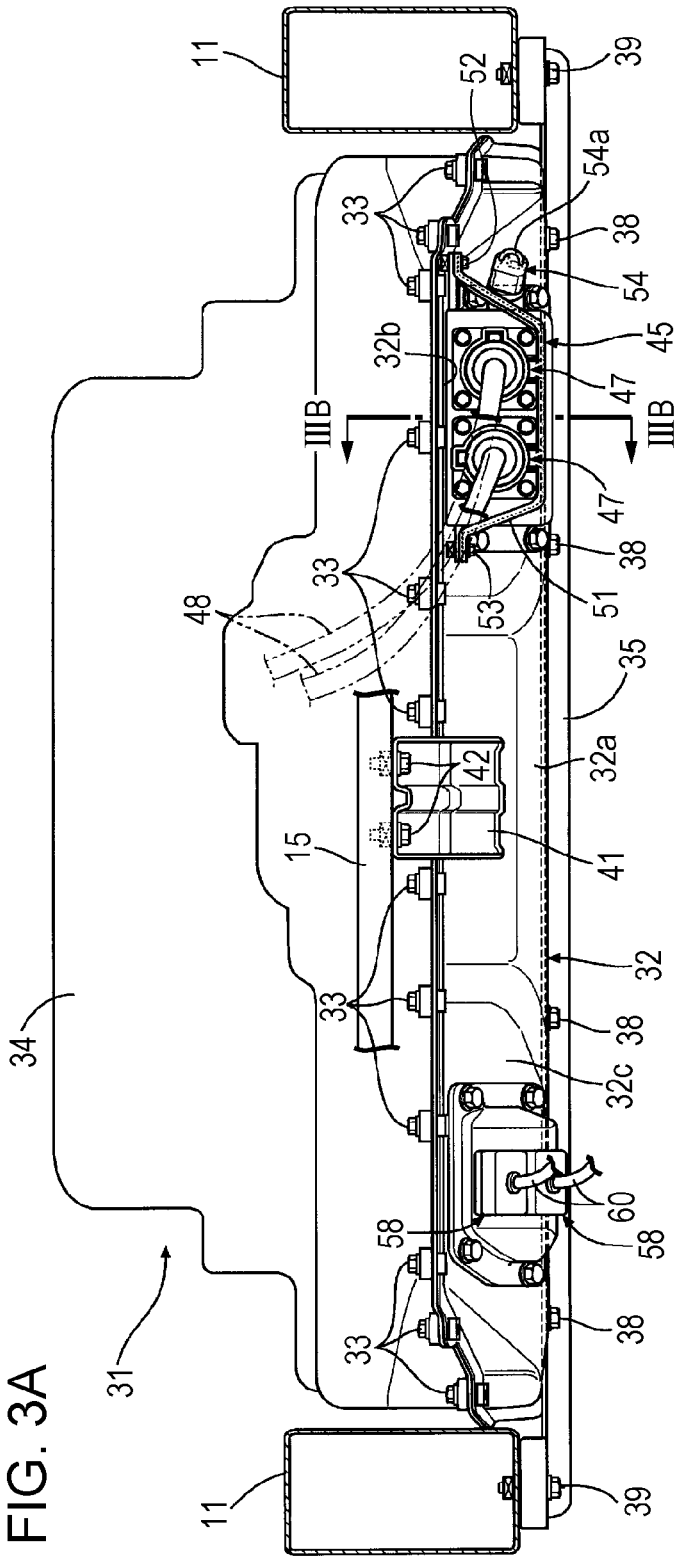

11
52
39
54a
33
38
54
45
32b
47
IIIB
IIIB
47
38
48
33
53
51
35
32a
42
41
15
32
33
38
32c
34
60
58
58
38
33
31
11
39

FIG. 3A

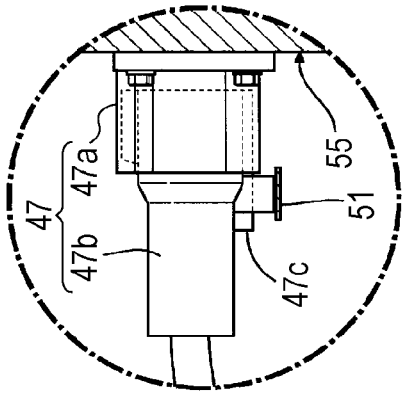

55
47
47a
51
47b
47c

FIG. 3B

FIG. 4

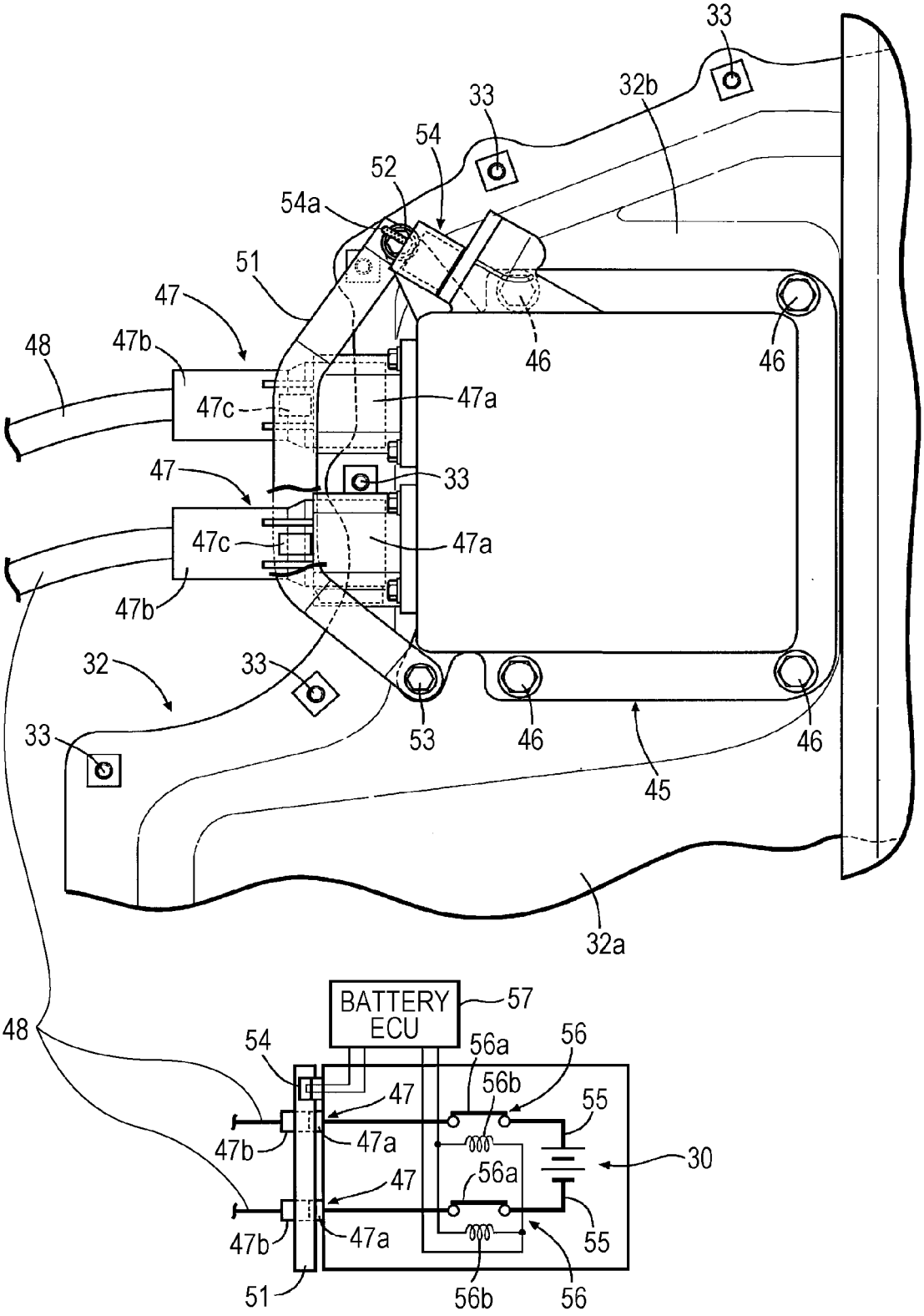
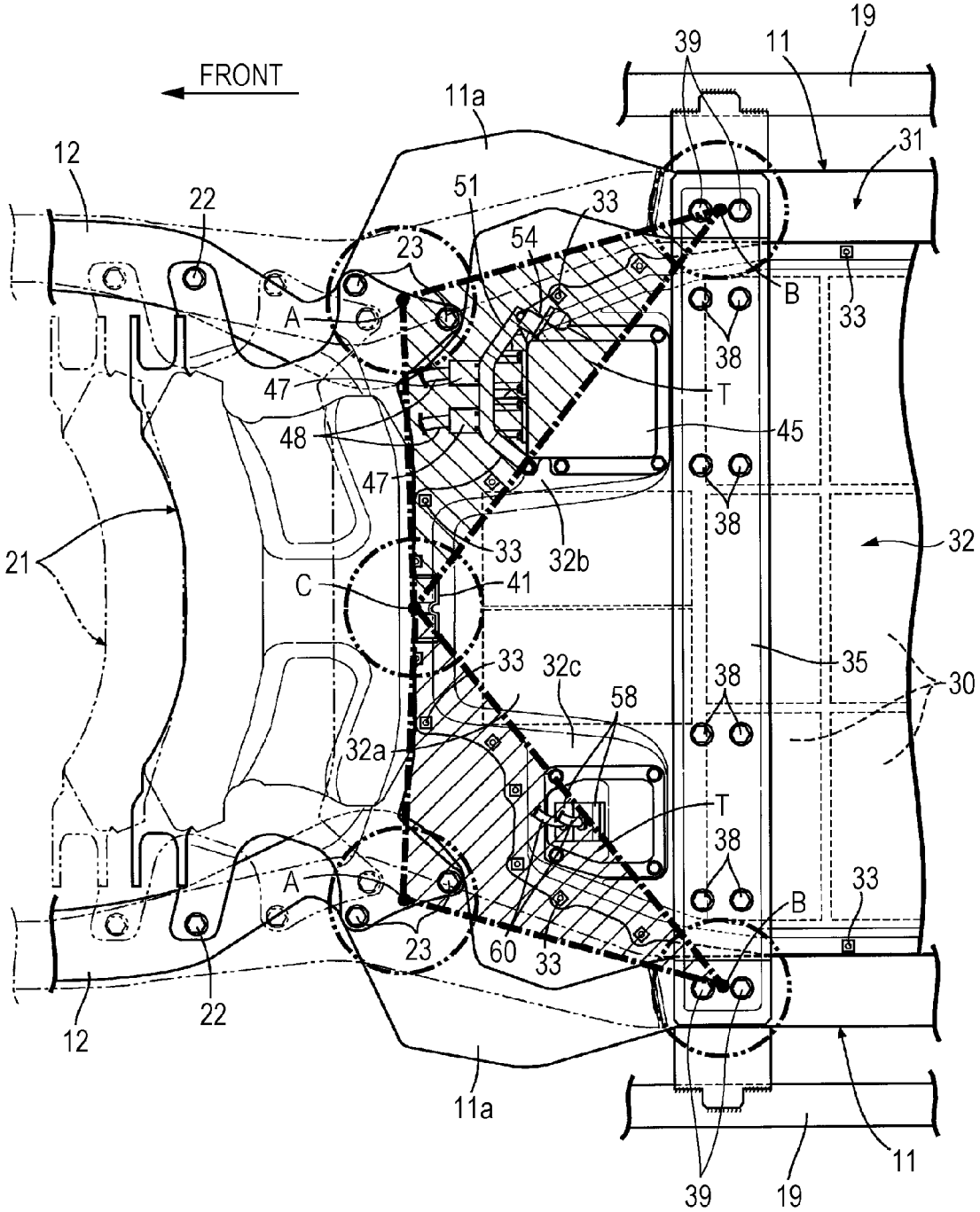

33
32b
33
54
52
54a
51
47
48
47b
47c
47a
46
46
47
33
47c
47a
47b
32
33
33
53
46
46
45
32a
48
BATTERY ECU
57
54
56a
56
47
56b
55
47b
47a
30
47
56a
47b
47a
55
51
56b
56

FIG. 5


FRONT
19
39
11
11a
31
12
22
51
33
54
23
A
B
33
38
47
T
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45
47
38
21
33
32b
32
C
41
33
32c
35
30
38
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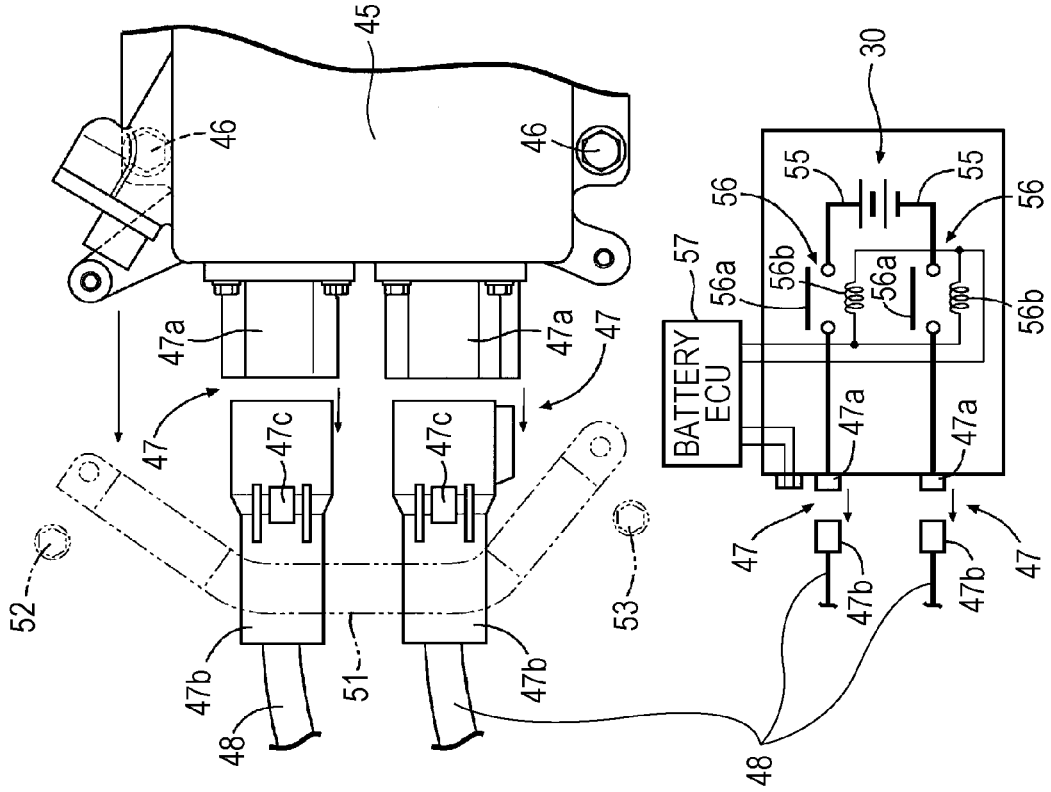
32a
T
38
A
B
33
23
60
33
12
22
11a
11
39
19

FIG. 6B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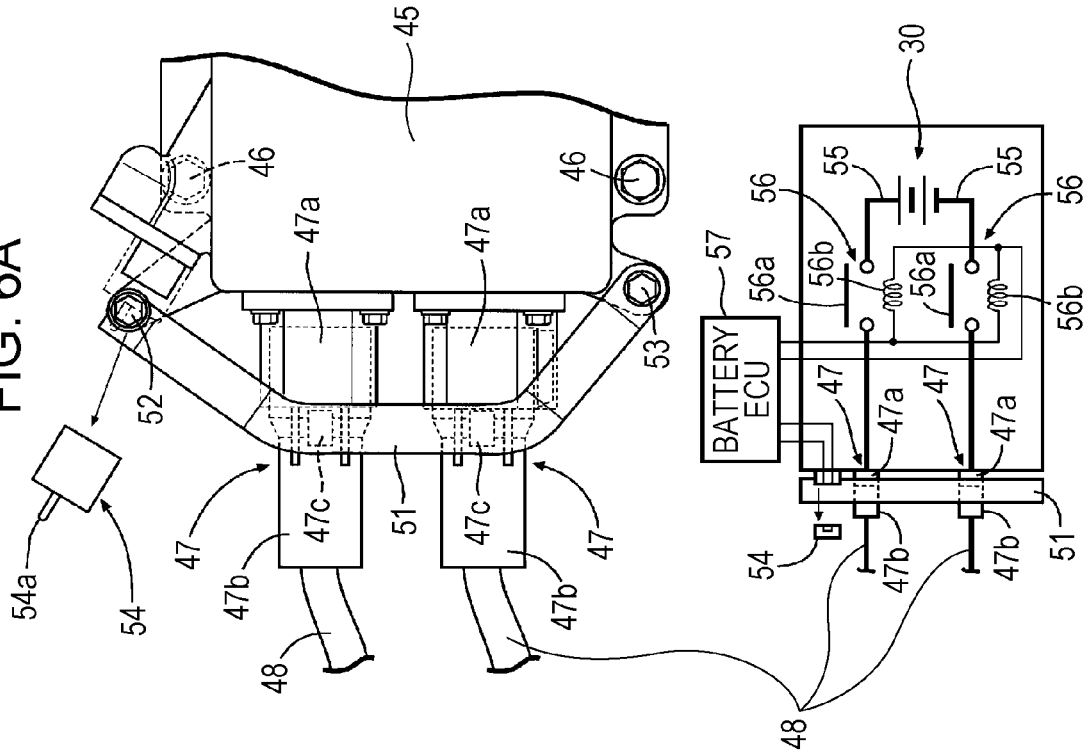
46
46
47a
47a
47
47
47c
47c
52
53
47b
47b
51
48
30
55
55
56
56
57
56a
56b
56a
56b
BATTERY ECU
47a
47a
47
47
47b
47b
48

FIG. 6A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47
47
47c
47c
51
47b
47b
48
30
55
55
56
56
57
56a
56b
56a
56b
BATTERY ECU
47
47
47a
47a
54
47b
47b
51
48

POWER SUPPLY SYSTEM FOR ELECTRIC VEHICLE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority under 35 U.S.C. §119 to Japanese Patent Application No. 2011-248431, filed Nov. 14, 2011, entitled "Power Supply System for Electric Vehicle." The contents of this application are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present application relates to a power supply system for an electric vehicle.

2. Discussion of the Background

Japanese Unexamined Patent Application Publication No. 2008-53128 discloses a configuration in which a lid that covers an upper opening of a body case containing a battery is connected to a breaker that breaks an electrical connection between the battery and a connector, such that the lid and the breaker can be interlocked with each other. In this configuration, when the lid is opened for battery maintenance, the breaker is automatically held at the breaking position.

When a connector of a power line that supplies power to a power drive unit of a motor generator is removed from a battery pack for maintenance etc., it is necessary to separate the connector from batteries so that a high voltage is not applied to the connector. In the technique disclosed in Japanese Unexamined Patent Application Publication No. 2008-53128, an operator pulls out a service plug to interrupt the application of a high voltage to the connector.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, a power supply system for an electric vehicle includes a battery, a power line, a connector, a separating operation device, a switch device, a switching operation member, and an interlock member. The battery is mounted on a vehicle body of the electric vehicle. Power is to be supplied via the power line from the battery to an electric apparatus provided in the electric vehicle. The connector is to removably connect the power line to the battery. The separating operation device is mounted on the connector and is configured to be operated by an operator to disconnect the connector. The switch device is configured to interrupt an electrical connection between the battery and the connector. The switching operation member is configured to be operated by the operator to open the switch device to interrupt the electrical connection. The interlock member is movable from a first position to a second position if the switching operation member has been operated by the operator to open the switch device to interrupt the electrical connection. The interlock member is configured to prohibit, at the first position, the operator from operating the separating operation device. The interlock member is configured to allow, at the second position, the operator to operate the separating operation device.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings.

FIG. **1** is a side view of an electric vehicle.

FIG. **2** illustrates the electric vehicle as viewed in the direction of arrow II in FIG. **1**.

FIG. **3**A is a cross-sectional view taken along line IIIA-IIIA of FIG. **2**, and FIG. **3**B is a cross-sectional view taken along line IIIB-IIIB of FIG. **3**A.

FIG. **4** is an enlarged view of area IV in FIG. **2**.

FIG. **5** illustrates an action that takes place in the event of a front-end collision.

FIG. **6**A and FIG. **6**B illustrate actions that take place in separation of high-voltage connectors.

DESCRIPTION OF THE EMBODIMENTS

The embodiments will now be described with reference to the accompanying drawings, wherein like reference numerals designate corresponding or identical elements throughout the various drawings.

As illustrated in FIG. **1** to FIGS. **3**A and **3**B, a vehicle body frame of an electric vehicle includes a pair of left and right floor frames **11** and **11** extending in the front and rear direction of the vehicle body. A pair of left and right front side frames **12** and **12** extends frontward and upward from respective front ends of the left and right floor frames **11** and **11**. A pair of left and right rear side frames **13** and **13** extends rearward and upward from respective rear ends of the left and right floor frames **11** and **11**.

Front ends of the left and right front side frames **12** and **12** are connected to each other by a front bumper beam **14** extending in the vehicle width direction. Front ends of the left and right floor frames **11** and **11** are connected to each other by a front cross member **15** extending in the vehicle width direction. Middle portions of the left and right floor frames **11** and **11** in the front and rear direction of the vehicle body are connected to each other by a middle cross member **16** extending in the vehicle width direction. Middle portions of the left and right rear side frames **13** and **13** in the front and rear direction of the vehicle body are connected to each other by a rear cross member **17** extending in the vehicle width direction. Rear ends of the left and right rear side frames **13** and **13** are connected to each other by a rear bumper beam **18** extending in the vehicle width direction.

A pair of left and right side sills **19** and **19** is disposed outside the left and right floor frames **11** and **11** in the vehicle width direction and extends in the front and rear direction of the vehicle body. Front ends of the left and right side sills **19** and **19** and rear ends of the left and right front side frames **12** and **12** are connected to each other by a pair of left and right front outriggers **20** and **20** extending in the vehicle width direction. Rear ends of the left and right side sills **19** and **19** are connected to respective front ends of the left and right rear side frames **13** and **13**.

A plate-like front subframe **21** is secured at the front thereof, with one bolt **22** each on the left and right sides, to lower surfaces of middle portions of the front side frames **12** and **12** in the front and rear direction of the vehicle body. The front subframe **21** is also secured at the rear thereof, with two bolts **23** and **23** each on the left and right sides, to lower surfaces of rear portions of the front side frames **12** and **12**. Front portions of the left and right front side frames **12** and **12** are connected to each other by a front mount beam **24** extending in the vehicle width direction. A motor generator **25** serving as a drive source for running the electric vehicle is provided with a rear mount bracket **26** at the rear thereof supported by a rear mount **27** on an upper surface of the front

subframe **21**. The motor generator **25** is also provided with a pair of left and right front mount brackets **28** and **28** at the front thereof supported by a pair of left and right front mounts **29** and **29** on a lower surface of the front mount beam **24**.

A battery pack **31** (a fixed device, a battery housing) that contains a plurality of battery modules **30** (see FIG. **2**) serving as a power source for the motor generator **25** includes a metal battery tray **32** and a battery cover **34**. The battery tray **32** holds the battery modules **30**, and the battery cover **34** is attached to the battery tray **32** with a plurality of bolts **33** on an upper surface of the battery tray **32**. The battery tray **32** has an internal hollow space through which cooling air passes to cool the battery modules **30**.

Three suspended beams **35**, **36**, and **37** extending in the vehicle width direction are secured with bolts **38** to a lower surface of the battery pack **31**. The suspended beam **35** on the foremost side is secured at both ends thereof, with bolts **39**, to lower surfaces of the left and right floor frames **11** and **11**. The suspended beam **36** in the middle is secured at both ends thereof to the lower surfaces of the left and right floor frames **11** and **11**. The suspended beam **37** on the rearmost side is secured at both ends thereof, through a pair of left and right brackets **40** and **40**, to side faces of the left and right rear side frames **13** and **13**. A bracket **41** at a front end of the battery pack **31** is secured with bolts **42** and **42** to a lower surface of the front cross member **15**. A bracket **43** at a rear end of the battery pack **31** is secured with bolts (not shown) to a lower surface of the rear cross member **17**.

When the battery tray **32** is supported by the vehicle body frame, a rear end of the front subframe **21** and a protruding portion **32***a* protruding frontward from the front end of the battery pack **31** face each other in the front and rear direction, with a predetermined gap α (see FIG. **2**) interposed therebetween.

Oblique portions (each surrounded by a two-dot chain line in FIG. **2**) at the front of the left and right floor frames **11** and **11** are shock absorbing members **11***a* and **11***a*. The shock absorbing members **11***a* and **11***a* are not designed to be crushable zones which are particularly breakable, but they can be collapsed when excessive shock is input to the vehicle in the event of a front-end collision. In such a front-end collision of the vehicle, other parts of the vehicle body frame, other than the shock absorbing members **11***a* and **11***a*, can also be collapsed. Since the front subframe **21** and the battery pack **31** have high rigidity, the amount of their deformation in the event of the front-end collision is smaller than the amount of deformation of the shock absorbing members **11***a* and **11***a*.

As illustrated in FIG. **5**, areas where the shock absorbing members **11***a* and **11***a* of the floor frames **11** and **11** are connected at front ends thereof, with the bolts **23**, to both left and right ends of the front subframe **21** are first connection portions A and A. Similarly, areas where the shock absorbing members **11***a* and **11***a* of the floor frames **11** and **11** are connected at rear ends thereof, with the bolts **39**, to both left and right ends of the battery pack **31** (i.e., to both left and right ends of the suspended beam **35** on the foremost side) are second connection portions B and B.

As illustrated in FIG. **2** to FIG. **4**, the battery tray **32** of the battery pack **31** has a recessed portion **32***b* at the rear and to the left of the protruding portion **32***a*. The recessed portion **32***b* is recessed upward. A high-voltage connector box **45** is secured with four bolts **46** to the recessed portion **32***b*. A pair of high-voltage connectors **47** and **47** (a connector) includes female connectors **47***a* and **47***a* (a first connector) secured to the front of the high-voltage connector box **45**, and male connectors **47***b* and **47***b* (a second connector) that can be inserted into and removed from the female connectors **47***a* and **47***a* in the front and rear direction. Two high-voltage (e.g., 288 V) power lines **48** and **48** (a power line) extending from the respective female connectors **47***a* and **47***a* are connected to a power drive unit **49** (see FIG. **1**) that controls the activation of the motor generator **25**.

An interlock member **51** formed by a bent plate is secured, at both ends thereof, with two bolts **52** and **53** which are inserted upward from below and screwed into the lower surface of the battery tray **32**. Lower surfaces of the female connectors **47***a* and **47***a* are provided with unlocking buttons **47***c* and **47***c* (a separating operation device). Unless the unlocking buttons **47***c* and **47***c* are pressed, the male connectors **47***b* and **47***b* are locked so as not to be removed from the female connectors **47***a* and **47***a*. When the interlock member **51** is secured to the battery tray **32**, the interlock member **51** is in the way and prevents the unlocking buttons **47***c* and **47***c* from being operated.

An interlock connector **54** (a switching operation member) having a handle **54***a* is placed on a side face of the high-voltage connector box **45** such that it can be inserted into and removed from the high-voltage connector box **45**. The handle **54***a* of the interlock connector **54** inserted on the side face of the high-voltage connector box **45** is located on the axis of the bolt **52** with which one end of the interlock member **51** is secured.

Contacts **56***a* and **56***a* of two relays **56** and **56** are placed between terminals **55** and **55** on both ends of the plurality of series-connected battery modules **30** and the pair of high-voltage connectors **47** and **47**. Coils **56***b* and **56***b* facing the respective contacts **56***a* and **56***a* are connected to a battery electronic control unit (ECU) **57** (a switch device, a detector), to which the interlock connector **54** is connected.

The battery tray **32** of the battery pack **31** has a recessed portion **32***c* at the rear and to the right of the protruding portion **32***a*. The recessed portion **32***c* is recessed upward. Female connectors of low-voltage connectors **58** and **58** are secured with four bolts to the recessed portion **32***c*. Two low-voltage (e.g., 12 V) power lines **60** and **60** extending from male connectors that can be inserted into and removed from the female connectors are connected to various vehicle-mounted devices.

The function of embodiments having the above-described configuration will now be described.

On the lower surface of the vehicle body frame, the rear end of the front subframe **21** on the front side and the front end of the battery pack **31** on the rear side face each other, with the gap a (see FIG. **2**) interposed therebetween. If an excessive collision load is input, in the front and rear direction of the vehicle body, to the front side frames **12** and **12** by a front-end collision, the shock absorbing members **11***a* and **11***a* formed by front portions of the floor frames **11** and **11** connected to the rear ends of the front side frames **12** and **12** are buckled as illustrated in FIG. **5**. Thus, the front subframe **21** is retracted and brings its rear end into contact with the front end of the battery pack **31**.

If the front subframe **21** and the battery pack **31** can come into contact with each other at a contact point C, a pair of left and right triangular regions T and T (each indicated by a dash-dot chain line in FIG. **5**) can be formed by the first connection portions A and A, the second connection portions B and B, and the contact point C. The triangular regions T and T are of high rigidity surrounded by the front subframe **21**, the battery pack **31**, and the shock absorbing members **11***a* and **11***a* buckled by the collision load. The high-voltage connectors **47** and **47** are disposed within one of the triangular regions T and T and the low-voltage connectors **58** and **58** are disposed within the other of the triangular regions T and T.

This can provide protection to the high-voltage connectors **47** and **47** and the low-voltage connectors **58** and **58**.

As described above, since the triangular regions T and T are defined on the basis of the positions of the first connection portions A and A, the second connection portions B and B, and the contact point C after the shock absorbing members **11***a* and **11***a* are deformed by the collision load, it is possible to more reliably prevent the high-voltage connectors **47** and **47** and the low-voltage connectors **58** and **58** from being damaged by collision. In particular, if the high-voltage connectors **47** and **47** are damaged and a ground fault occurs in the vehicle body frame, there is a danger of electric shock. With the configuration of the present embodiment, it is possible to reliably prevent occurrence of the ground fault.

For example, when the male connectors **47***b* and **47***b* are pulled out of the female connectors **47***a* and **47***a* of the high-voltage connectors **47** and **47** for replacement of the battery pack **31**, there is a danger of electric shock if a voltage as high as 288 V is applied to the high-voltage connectors **47** and **47**. To prevent electric shock, it is necessary to interrupt in advance the application of a high voltage to the high-voltage connectors **47** and **47**. When the interlock connector **54** is pulled out as illustrated in FIG. **6**A, the battery ECU **57** detects it and stops the flow of current to the coils **56***b* and **56***b* of the relays **56** and **56**. Thus, the contacts **56***a* and **56***a* open and interrupt the application of a high voltage to the high-voltage connectors **47** and **47**.

To pull out the male connectors **47***b* and **47***b* from the female connectors **47***a* and **47***a* of the high-voltage connectors **47** and **47**, it is necessary to press the unlocking buttons **47***c* and **47***c* on the male connectors **47***b* and **47***b*. However, when the interlock member **51** is mounted, the unlocking buttons **47***c* and **47***c* are hidden and thus cannot be pressed. To press the unlocking buttons **47***c* and **47***c*, it is necessary to loosen the two bolts **52** and **53** with a tool and remove the interlock member **51**. Since the interlock connector **54** has already been pulled out, the bolt **52** (a fixing member) can be loosened with the tool without causing interference with the interlock connector **54**. Thus, as illustrated in FIG. **6**B, it is possible to remove the interlock member **51**, press the unlocking buttons **47***c* and **47***c*, and pull out the male connectors **47***b* and **47***b* from the female connectors **47***a* and **47***a*.

Even if the operator attempts to remove the interlock member **51** without pulling out the interlock connector **54**, the bolt **52** cannot be loosened due to interference of the tool with the interlock connector **54** as illustrated in FIG. **4**. Thus, since the unlocking buttons **47***c* and **47***c* cannot be pressed and the male connectors **47***b* and **47***b* cannot be pulled out of the female connectors **47***a* and **47***a*, it is possible to prevent the occurrence of electric shock accidents.

Although embodiments of the present application have been described, various design changes can be made without departing from the scope of the present application.

For example, the present application is applicable not only to electric vehicles having only a motor generator as a running drive source, but also to hybrid vehicles having both an engine and a motor generator as a running drive source.

Also, the opening/closing operation member of the present application is not limited to the interlock connector **54** of the embodiments, but may be a switch or anything that outputs a signal for opening the relays **56** and **56** (a switch device, a switching circuit) to the battery ECU **57**.

Also, the fixing member of the present application is not limited to the bolt **52** of the embodiments, but may be a clip or anything as long as the interlock member **51** can be secured in place.

The shape of the interlock member **51** is not limited to that in the embodiments described above.

According to a first aspect of the embodiment, a power supply system for an electric vehicle is proposed which includes a battery mounted on a vehicle body, a power line configured to supply power from the battery to the outside, a connector configured to removably connect the power line to the battery, a separating operation unit mounted on the connector and operated to disconnect the connector, an opening/closing unit capable of interrupting an electrical connection between the battery and the connector, an opening/closing operation member operated by an operator and configured to open the opening/closing unit to interrupt the electrical connection, and an interlock member configured to be movable between a first position that prohibits the operator from operating the separating operation unit and a second position that allows the operator to operate the separating operation unit. In the power supply system, when the opening/closing operation member is operated to interrupt the electrical connection made through the opening/closing unit, the interlock member can be moved to the second position.

In the configuration of the first aspect of the embodiment, when the opening/closing operation member is not being operated by the operator, the opening/closing unit is closed and a high voltage is applied to the connector to maintain the electrical connection between the battery and the connector. In this state, even if the operator attempts to move the interlock member from the first position to the second position to separate the connector, the interlock member disables the operation of the separating operation unit of the connector, so that accidental separation of the connector can be reliably prevented. When the operator operates the opening/closing operation member, the opening/closing unit is opened to interrupt the electrical connection between the battery and the connector, so that application of a high voltage to the connector is stopped. In this state, even when the operator moves the interlock member from the first position to the second position to separate the connector, safety can be ensured because a high voltage is no longer applied to the connector.

According to a second aspect of the embodiment, in the configuration of the first aspect, the interlock member is a plate-like member configured to cover the separating operation unit and secured to a fixed unit with a fixing member. When the opening/closing operation member is moved to a position that allows interruption of the electrical connection, removal of the fixing member is enabled.

In the configuration of the second aspect of the embodiment, the interlock member is a plate-like member configured to cover the separating operation unit and secured to the fixed unit with the fixing member. Therefore, when the opening/closing operation member is not being operated, the interlock member reliably covers the separating operation unit of the connector. This can reliably prevent operation of the separating operation unit and separation of the connector. When the opening/closing operation member is operated to interrupt the electrical connection, the opening/closing operation member is moved to a position which does not interfere with removal of the fixing member. Thus, by removing the fixing member, it is possible to move the interlock member from the first position to the second position, make the separating operation unit operable, and separate the connector.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A power supply system for an electric vehicle, comprising:

a battery mounted on a vehicle body of the electric vehicle;

a power line via which power is to be supplied from the battery to an electric apparatus provided in the electric vehicle;

a connector to removably connect the power line to the battery;

a separating operation device mounted on the connector and configured to be operated by an operator to disconnect the connector;

a switch device configured to interrupt an electrical connection between the battery and the connector;

a switching operation member configured to be operated by the operator to open the switch device to interrupt the electrical connection; and

an interlock member movable from a first position to a second position so as to allow the operator to operate the separating operation device if the switching operation member has been operated by the operator to open the switch device to interrupt the electrical connection, the interlock member being configured to hide, at the first position, the separating operation device to prohibit the operator from operating the separating operation device, the interlock member being configured to allow, at the second position which is a different position from the first position, the operator to operate the separating operation device.

2. The power supply system according to claim 1, further comprising:

a fixing member to secure the interlock member to a fixed device provided in the electric vehicle at the first position,

wherein the interlock member covers the separating operation device to prohibit the operator from operating the separating operation device if the interlock member is disposed at the first position, and

wherein the fixing member is removable from the fixed device if the switching operation member has been operated by the operator to move to a disconnecting position at which the switch device interrupts the electrical connection.

3. The power supply system according to claim 2,

wherein the switch device is configured to make and interrupt the electrical connection between the battery and the connector, and

wherein the switching operation member is movable between the disconnecting position and a connecting position at which the switch device makes the electrical connection.

4. The power supply system according to claim 3,

wherein the switching operation member prohibits the operator from removing the fixing member from the fixed device when the switching operation member is disposed at the connecting position.

5. The power supply system according to claim 4,

wherein the switch device comprises

a detector configured to detect that the switching operation member is removed from the connecting position, and

a switching circuit configured to interrupt the electrical connection between the battery and the connector if the detector detects that the switching operation member is removed from the connecting position.

6. The power supply system according to claim 2,

wherein the fixed device comprises a battery housing in which the battery is provided.

7. The power supply system according to claim 1,

wherein the electric apparatus comprises at least one of

a motor generator configured to generate a driving force for the electric vehicle, and

a control device configured to control the motor generator.

8. The power supply system according to claim 1,

wherein the connector comprises

a first connector connected to the battery, and

a second connector connected to the power line and removably connected to the first connector, and

wherein the separating operation device is configured to lock the second connector not to be removed from the first connector, and is configured to be operated by the operator to unlock the second connector to be removable from the first connector.

9. The power supply system according to claim 1,

wherein the connector includes a male part and a female part and the separating operation device is configured to lock and unlock the connector, and wherein

when the connector is locked, the male and female parts are locked together, and when the connector is unlocked, the connector is configured to be pulled by the operator to disconnect the male part and the female part and to physically disconnect the power line from the battery.

10. The power supply system according to claim 1,

wherein the switch device interrupts the electrical connection between the battery and the connector in response to a removal of the switching operation member.

11. The power supply system according to claim 1, further comprising:

a high-voltage connector box that houses the switch device,

wherein the switching operation member is removably coupled to the high-voltage connector box such that the interlock member is movable to the second position only when the switching operation member is removed from the high-voltage connector box.

12. The power supply system according to claim 1, further comprising:

a bolt that secures the interlock member in the first position,

wherein the switching operation member prevents access to the bolt when the switching operation member is in electrical communication with the switch device.

13. The power line supply system according to claim 1,

wherein the separating operation device includes a button on the connector, the button configured to be pressed to unlock the connector.

14. The power supply system according to claim 13,

wherein the interlock member is a plate-like member that physically blocks the button when the interlock member is in the first position.

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